SEARCH FOR SUGARS AND RELATED COMPOUNDS IN RESIDUES PRODUCED FROM THE UV IRRADIATION OF ASTROPHYSICAL ICE ANALOGS.

S. A. Sandford[1], M. Nuevo[1,2], C. K. Materese[1,3], and G. W. Cooper[1]. [1]NASA Ames Research Center, Moffett Field, CA, USA. E-mail: Scott.A.Sandford@nasa.gov. [2]BAER Institute, Petaluma, CA, USA. [3]ORAU, Oak Ridge, TN, USA.

Introduction: A large variety of organics of biological and prebiotic interests have been detected in meteorites, including one sugar and several sugar acids and sugar alcohols [1]. The presence of these compounds in meteorites, along with amino acids, amphiphiles, and nucleobases [2–4], indicates that molecules essential to life can be formed abiotically under astrophysical conditions. This hypothesis is supported by extensive laboratory studies involving the formation of complex organic molecules from the ultraviolet (UV) irradiation of astrophysical ice analogs (H_2O, CO, CO_2, CH_3OH, CH_4, NH_3, etc.). These studies show that the organic residues recovered at room temperature contain many of the same compounds as those found in meteorites [3,5–8]. However, to the best of our knowledge, no systematic search for the presence of sugars and sugar derivatives in such laboratory residues have been reported to date. Only a limited number of small (<4 C atoms) sugar-related compounds such as glycerol and glyceric acid [9], and more recently small (2–4 C atoms) aldehydes [10] have been detected in residues.

Experiments: Pure CH_3OH and H_2O+CH_3OH mixtures in proportions 5:1, 2:1, and 1:1 were deposited onto a cold substrate (<10 K) inside a high-vacuum chamber (~10^{-8} torr). While being deposited, the ice layers were simultaneously irradiated with an H_2-discharge UV lamp [8]. After irradiation, samples were warmed to 300 K under vacuum to allow for the original volatiles to sublime away. The remaining refractory materials (the "residues") were extracted from the sample chamber and analyzed with gas chromatography coupled with mass spectrometry (GC-MS).

Preliminary results: The GC-MS analysis of residues produced from the UV irradiation of several H_2O+CH_3OH ice mixtures confirm the presence of small (2–4 C atoms) sugar acids and sugar alcohols. Our method is currently being improved to detect larger (5- and 6-C atoms) compounds in the residues, as well as to retain the original sugars in the residues. Once a list of produced compounds established, experimental data will be compared with measurements of the same compounds in primitive meteorites. Future experiments will examine the extent to which the production of these compounds is modified by the presence of N-bearing ices species.

References: [1] Cooper G. W. et al. 2001. *Nature* 414:879–883. [2] Kvenvolden K. et al. 1970. *Nature* 228:923–926. [3] Dworkin J. P. et al. 2001. *Proceedings of the National Academy of Sciences* 98:815–819. [4] Folsome C. E. et al. 1971. *Nature* 232 :108–109. [5] Bernstein M. P. et al. 2002. *Nature* 416:401–403. [6] Muñoz Caro G. M. et al. 2002. *Nature* 416:403–406. [7] Nuevo M. et al. 2008. *Origins of Life and Evolution of Biospheres* 38:37–56. [8] Nuevo M. et al. 2014. *Astrophysical Journal* 793:125. [9] Nuevo M. et al. 2010. *Astrobiology* 10:245–256. [10] de Marcellus P. et al. 2015. *Proceedings of the National Academy of Sciences* 112:965–970.